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Approved

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ABSTRACT

To satisfy requirements of the Federal Facility Agreement and Consent Order with the State of Idaho and the U.S. Environmental Protection Agency, the U.S. Department of Energy is conducting the Waste Area Group 7 Operable Unit 13/14 comprehensive remedial investigation/feasibility study at the Idaho National Engineering and Environmental Laboratory.

This preliminary evaluation of remedial alternatives supports future development of the Waste Area Group 7 feasibility study. The preliminary evaluation of remedial alternatives identifies and screens potential technologies and assorted process options that could be applied at the Waste Area Group 7 Subsurface Disposal Area, a radioactive and mixed waste landfill. After screening, selected process options are assembled into possible alternatives for remediating the landfill. These alternatives then are evaluated according to their effectiveness, implementability, and cost, as specified by the Comprehensive Environmental Response, Compensation, and Liability Act. Alternatives failing to meet the specified criteria are eliminated from further evaluation. Remaining alternatives then undergo individual and comparative analyses.

Discussions and analyses in this report can be used to define scope for the Waste Area Group 7 remedial investigation/feasibility study and to provide useful information to support future risk management decisions for the site. This study does not promote any single alternative as a candidate for final selection, but identifies a range of alternatives from which the U.S. Department of Energy, the State of Idaho, and the U.S. Environmental Protection Agency can select for remediating Operable Unit 13/14.

EXECUTIVE SUMMARY

E1. SUMMARY OF THE PRELIMINARY EVALUATION OF REMEDIAL ALTENATIVES

This *Preliminary Evaluation of Remedial Alternatives* (PERA) identifies a range of potential remedial options that offer effective treatment for contaminated conditions at the Radioactive Waste Management Complex (RWMC), which has been designated as Waste Area Group (WAG) 7 at the Idaho National Engineering and Environmental Laboratory (INEEL). Evaluation presented in this report is limited to the Subsurface Disposal Area (SDA), a radioactive and mixed waste landfill at the RWMC, to support development of the WAG 7 comprehensive remedial investigation/feasibility study (RI/FS), Operable Unit (OU) 7-13/14. The RI/FS is being conducted under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (42 USC § 9601 et seq.), as implemented by the *Federal Facility Agreement and Consent* Order (DOE-ID 1991). This PERA is a precursor to the RI/FS, and provides a framework for scoping the OU 7-13/14 project and completing the RI/FS.

The primary focus of this PERA is to identify remedial options for buried waste (i.e., source term) within the SDA, an area defined by limits of the pits, trenches, soil vaults, and impacted soil extending to the interface with the underlying basalt. The PERA does not directly address remediation requirements for existing contamination within adjacent media (i.e., surface water, air, vadose zone, and groundwater). Instead, it evaluates remedial options designed to (1) control future human or ecological exposure to the waste, and (2) reduce future contaminant releases from the SDA source term into the surrounding environment. This PERA also does not directly address the adjacent Transuranic Storage Area (TSA). However, as appropriate, DOE will incorporate the final CERCLA remedial alternative in the closure of the Resource Conservation and Recovery Act (42 USC § 6901 et seq.) (RCRA)-permitted storage cells within the TSA.

The PERA follows a step-by-step process to identify remedial alternatives that potentially eliminate, reduce, or mitigate risks posed by WAG 7. This defined approach is designed to methodically screen technologies, assemble and evaluate individual alternatives, and then analyze comparative advantages and disadvantages offered by each possible remedy. Organization of the PERA closely follows the sequenced screening of technologies and development of remedial alternatives prescribed in feasibility study guidance (EPA 1988). The framework of the report along with a summary of the site environmental setting is presented in Section 1.

E2. REMEDIAL ACTION OBJECTIVES

Section 2 has an overview of the CERCLA requirements, remedial action objectives (RAOs), preliminary remediation goals, and applicable or relevant and appropriate requirements (ARARs) for WAG 7. This regulatory framework established the context in which the PERA was developed.

The RAOs for WAG 7 reflect site-specific human health and ecological risk goals specific to contaminants of concern (COCs) and exposure pathways identified in the *Ancillary Basis for Risk Analysis* (ABRA) (Holdren et al. 2002). Achieving these RAOs is predicated on the assumption that previous releases of contaminants from the source term (i.e., postulated contamination within the vadose zone) will not have a significant impact on adjacent environmental media. An additional assumption for this PERA is that DOE or another government agency will retain control of the SDA in perpetuity and that final CERCLA actions will include capping and enforced institutional controls to ensure protectiveness for contamination remaining at the RWMC.

The ABRA (Holdren et al. 2002) concluded that the media of primary concern for the WAG 7 PERA are soil, dust, and groundwater. However, this PERA and the WAG 7 feasibility study will focus on remedial alternatives that mitigate contamination within the source term only; technology applications for remediating area groundwater are not directly addressed. To protect groundwater in the future, this PERA evaluates measures to control the source term through specific technology applications that contain or treat COC-bearing waste streams and inhibit future contaminant migration.

Remedial Action Objectives for WAG 7

- Limit the cumulative human-health cancer risk for soil and groundwater exposure pathways to less than or equal to 1E-04
- Limit the noncancer risk for soil and groundwater exposure pathways to a cumulative hazard index of less than 2 for current and future workers and future residents
- Inhibit migration of contaminants of concern (COCs) to groundwater
- Inhibit ecological receptor exposures to COCs in soil and waste with concentrations greater than or equal to 10 times background values, resulting in a hazard quotient greater than or equal to 10
- Inhibit transport of COCs to the surface by plants and animals.

The final chemical-, location-, and action-specific ARARs ultimately identified for WAG 7 will be selected by the regulatory agencies, with input from project stakeholders. Therefore, the ARARs identified during the PERA serve only as screening criteria for evaluating alternatives. Further, only potential ARARs that protect human health and the environment during and following implementation of a given remedial action alternative are identified. Appendix A contains listings of the preliminary ARARs identified for WAG 7. In addition, the PERA considers other factors, designated as to-be-considered requirements, that may influence elements of an alternative, and include unpromulgated standards, criteria, advisories, and specific U.S. DOE orders. These to-be-considered requirements are not legally binding and are used only for screening purposes.

E3. WASTE STREAMS OF CONCERN

Disposal of transuranic (TRU) and mixed waste, mostly from the Rocky Flats Plant (RFP) in Colorado, occurred at the SDA through 1970. Mixed low-level waste containing hazardous chemical and radioactive contaminants was disposed of through 1984. Since 1985, waste disposals in the SDA have been limited to low-level radioactive waste from the INEEL waste generators. A large volume of waste resulted from construction, operation, and decommissioning of INEEL nuclear reactor testing programs. Various containers were used in shipping and disposing of waste in metal drums, cardboard cartons, and wooden boxes. Larger individual items (e.g., tanks, furniture, process and laboratory equipment, engines, and vehicles) were placed separately as loose trash.

Remedial alternatives presented in this PERA could achieve RAOs by applying specific technologies to treat, isolate, immobilize, or remove waste containing identified COCs. Waste disposal sites within the SDA consist of subsurface pits, trenches, soil vault rows (SVRs), and an aboveground disposal site (Pad A). Figure E-1 shows the general locations of these sites within the SDA.

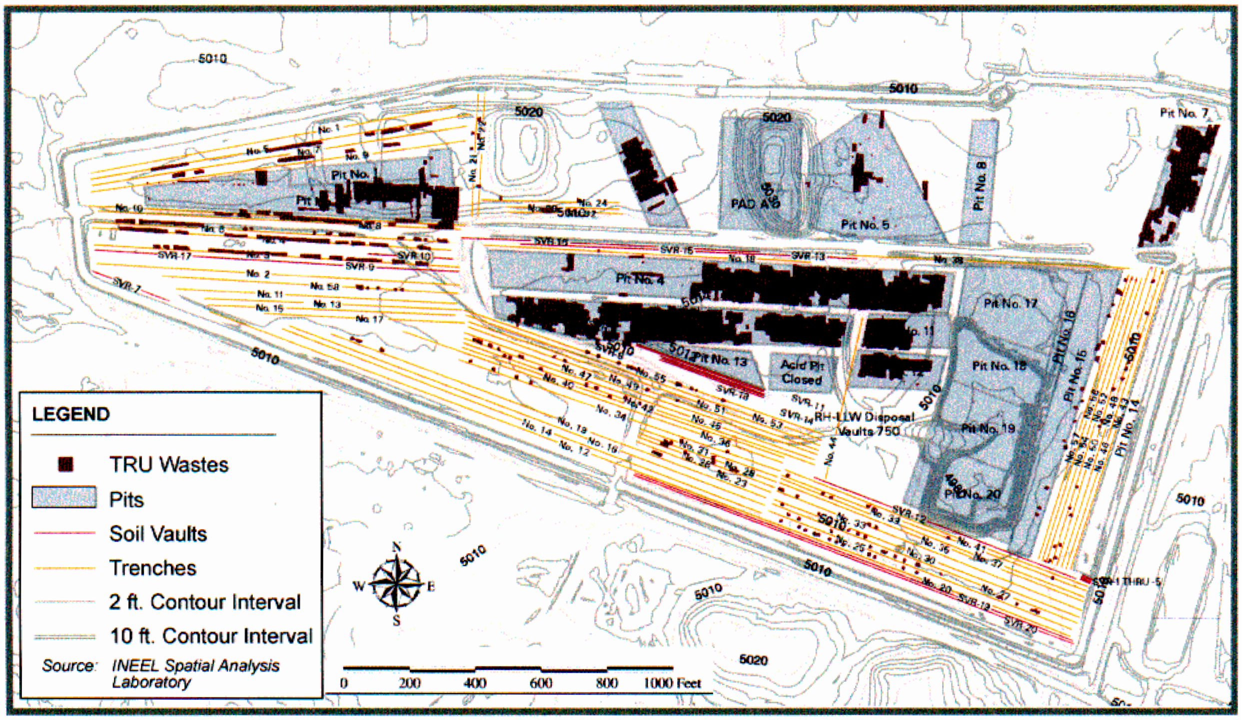

Figure E-1. Subsurface Disposal Area waste disposal units.

The ABRA identified human health and ecological COCs associated with buried waste. A total of 16 human health COCs were identified that exceeded either a 1E-05 carcinogenic risk or contributed to a cumulative noncarcinogenic hazard index of 2. The exposure pathway that contained the majority of the COCs and exhibited the highest degree of risk was groundwater ingestion. Other pathways having unacceptable risks from one or more of the COCs include soil ingestion, inhalation, external exposure, and crop ingestion from surface uptake. The ABRA also identified seven ecological COCs, based on a hazard quotient of 1 for radionuclides and 10 for nonradionuclides. The primary pathways of ecological concern were associated with burrowing animals and insects and plant ingestion.

Except for the No Action alternative, all alternatives include institutional controls and an engineered surface barrier over the SDA to preclude direct access to contamination remaining following remediation (DOE-ID 1998). The engineered barrier would mitigate surface exposure pathways (e.g., external exposure and crop ingestion) that contribute to human health risk. The cover also would address ecological COCs by inhibiting intrusion into the waste by plants, burrowing animals, and insects. Therefore, additional measures to address the surface exposure pathways to protect human health and the environment would not be required.

This PERA focuses on remediating specific COCs that represent groundwater risk drivers. The ABRA identified a number of constituents as groundwater COCs including organics, inorganics, toxic metals, and radionuclides. Based on disposal records, the COCs are concentrated in several waste forms:

- Actinides including Am-241, Np-237, Pu-238, Pu-239, Pu-240, U-233, U-234, U-235, U-236, and U-238—The majority of the long-lived, relatively immobile actinides are contained within the RFP sludge deposited in drums within TRU pits and trenches (i.e., Pits 1 through 6 and 9 through 12, Trenches 1 through 10) and Pad A.

- Activation and fission products including C-14, I-129, and Tc-99—Waste streams containing activation and fission products consist mainly of metal and scrap metal pieces, core loop components, core structural pieces, resins, and irradiated fuel material. These materials were buried in a variety of different container types, primarily as remote-handled waste in the SVRs and trenches.

- Volatile organic contaminants including carbon tetrachloride (CCL_4), tetrachloroethylene (PCE), and methlyene chloride—CCL_4 and PCE are contained almost entirely in drummed or bagged organic sludge (Series 743) from RFP and are located in the TRU pits and trenches. Methylene chloride also is contained almost entirely in the RFP shipments in waste streams consisting of sludge, paper, rags, plastic, equipment, and assorted debris.

- Nitrates—The nitrates within the SDA are located almost entirely in the drummed waste stream (Series 745 sludge) shipped from RFP between 1967 and 1970. Nitrate waste in the SDA is in Pad A; Pits 4, 6, 9, 10, and 11; and in isolated areas within the trenches and SVRs.

In addition to risk-based COCs identified in the ABRA, Am-241 and three plutonium isotopes were included as groundwater COCs. Though Am-241 also was not a direct COC for groundwater ingestion; the majority of Np-237 is created through Am-241 decay. Three plutonium isotopes—Pu-238, Pu-239, and Pu-240—were classified as special case groundwater COCs to acknowledge uncertainties about plutonium mobility in the environment and to reassure stakeholders that risk management decisions for the SDA will be fully protective (Holdren et al. 2002). Because most plutonium in the SDA is collocated with risk-based COCs that have similar properties, treating plutonium isotopes as COCs will have little effect on analysis of alternatives or on risk management decisions.

E4. IDENTIFICATION AND SCREENING OF REMEDIATION TECHNOLOGIES

Section 2 of the PERA considered a range of potential remedial technologies and process options that could be combined to form general response actions (GRAs). The GRAs for WAG 7, originally defined in the *RI/FS Work Plan* (Becker et al. 1996), have been modified and updated to reflect the revised conceptual model and emerging technologies. The GRAs developed as part of this PERA include no action, institutional controls, containment, in situ treatment, retrieval, ex situ treatment, and disposal.

Under each GRA, the PERA identifies numerous approaches and technologies with potential application to buried waste at WAG 7. For example, the containment GRA could be achieved using various remedial technologies, such as surface controls and diversions, surface barriers, lateral barriers, and subsurface horizontal barriers. In turn, these technologies could be implemented with various process options (e.g., possible lateral barriers include slurry walls, grout curtains, in situ soil mixing, sheet piling, in situ vitrification barriers, or ground freezing barriers). In Section 2, the technologies and their associated process options are individually evaluated against the criteria required by CERCLA as listed below:

- Effectiveness—Assesses the ability of each technology or process option to remediate waste media and meet RAOs.

- Implementability—Assesses the technical and administrative feasibility of each technology.

- Cost—Assesses costs, including relative estimates of capital cost and operation and maintenance.

Remedial technologies and process options that fail to adequately meet requirements of the above criteria during initial screening are eliminated from further analyses and consideration. For example, the INEEL Central Facilities Area was considered as an option under the disposal GRA, but was eliminated because the facility is limited to nonhazardous waste. Similarly, for each GRA, the screening process streamlines the list of available remedial technologies and process options, retaining only those that could meet the criteria for subsequent development and screening in Section 3. Appendix B provides details about the various process options and their final elimination or inclusion as part of an alternative.

E5. DEVELOPMENT AND SCREENING OF ALTERNATIVES

Section 3 presents seven preliminary remedial action alternatives assembled from the technologies and process options that passed initial screening. The alternatives provide a range of possible actions that address WAG 7 RAOs. The alternatives span the GRAs and are established around specific technology applications including containment, ISG, ISV, and RTD, as shown in Table E-1. The alternatives are structured to focus these specific technologies on the mitigation of risks resulting from the identified COCs.

Scope of remediation is based on available waste inventory data, which identify the extent and location of the waste streams deposited in the SDA that contain the COCs. Distribution of these contaminants is presented in the ABRA. As shown, the TRU COCs received from RFP are located in Pits 1 through 6, 9 through 12, Trenches 1 through 10, and Pad A. Activation and fission product COCs are located primarily in SVRs and remaining trench areas.

To establish a foundation for developing a comparative analysis, the alternatives apply specific technologies to the RFP TRU. Waste streams associated with the RFP waste contain the majority of the actinides (e.g., americium, neptunium, plutonium, and uranium,), nitrates, and volatile organic compounds (e.g., CCL_4, PCE, and methylene chloride). Each alternative also incorporates several supplemental technologies required to address waste stream-specific issues and achieve RAOs. All the alternatives involve long-term monitoring to evaluate the effectiveness of the remedial measures. All of the alternatives (with the exception of the No Action alternative) also involve institutional controls and placement of a surface barrier to protect any remaining buried waste at the site. In addition, other remedial actions that are common to two more of the alternatives include the following:

- In situ grouting in SVRs and trench areas that contain activation and fission product COCs
- Handling and treating Pad A waste
- Treating high organic waste areas using in situ thermal desorption (ISTD).

A summary of the application of these supplemental technologies for each of the alternatives is in Table E-2.

Following guidance from the U.S. Environmental Protection Agency (EPA 1988), each alternative is evaluated according to its ability to meet the CERCLA evaluation criteria for effectiveness, implementability, and cost in the context of the site conditions and extent of the required remedial action. As shown in Table E-2, the alternative screening process resulted in eliminating two preliminary alternatives. The Limited Action alternative was eliminated because it fails to meet WAG 7 RAOs. The Full Containment alternative was not retained for further analysis because of issues associated with implementation and cost effectiveness.

At the conclusion of the alternative screening processes discussed in Section 3, the five alternatives retained for detailed analysis are (1) no action, (2) surface barrier, (3) ISG, (4) ISV, and (5) RTD.

Table E-1. Alternative components.

Alternatives	Monitoring	Access Controls	Surface Barrier	Subsurface Barrier	In Situ Treatment	Retrieval	Ex Situ Treatment	On-Site Disposal	Off-Site Disposal	Representative Process Options
No Action	✓									
Limited Action	✓	✓	✓*							*Biotic Barrier
Surface Barrier	✓	✓	✓*							*Engineered Multi-Layer Cap
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD
Pad A Waste						✓		✓*		*Placed Beneath Cap
Full Containment	✓	✓	✓*	✓						*Engineered Multi-Layer Cap
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD
Pad A Waste						✓		✓*		*Placed Beneath Cap
In Situ Grouting	✓	✓	✓*							*Engineered Multi-Layer Cap
RFP Waste					✓*					*ISG
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD
Pad A Waste						✓	✓*	✓		*Ex Situ Stabilization
In Situ Vitrification	✓	✓	✓*							*Engineered Multi-Layer Cap
RFP Waste					✓*					*ISV
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD/ISV
Pad A Waste					✓*	✓				*ISV
Retrieval	✓	✓	✓*							*Engineered Multi-Layer Cap
RFP Waste						✓	✓	✓*	✓**	*On-Site Landfill - Non TRU Waste **WIPP Disposal - TRU Waste
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD
Pad A Waste						✓	✓	✓*		*On-Site Landfill

Table E-2. Remedial action alternatives.

Alternatives	Effectiveness	Implementability	Costs	Retained?
No Action	• Does not mitigate site risks	• Maintenance of existing monitoring programs only	• No capital costs • Long term monitoring costs only	Yes - In accordance with EPA directive
Limited Action	• Prevents direct exposure • Does not treat source • Does not mitigate projected groundwater impacts	• Standard earthwork • Does not require intrusion into the waste • Requires future groundwater use restrictions	• Low capital costs • Long term monitoring and maintenance costs	No - Does not achieve RAOs
Surface Barrier	• Prevents direct exposure • Surface Barrier reduces contaminant mobility and minimizes groundwater impacts • Does not reduce toxicity or volume of source • Activation/fission products in SVRs and trenches stabilized with ISG • VOCs in high organic waste streams destroyed with ISTD	• Short implementation period • Standard earthwork • Minor amount of intrusive work • 5M cy of material required for construction	• Capital costs significantly higher than Limited Action • Long term monitoring and maintenance costs	Yes - Achieves RAOs with lowest capital costs
Full Containment	• Prevents direct exposure • Reduction in contaminant mobility similar to surface barrier • Activation/fission products in SVRs and trenches stabilized with ISG • VOCs in high organic waste streams destroyed with ISTD	• Longer implementation period • Requires major extensive intrusive work • Implementation verification difficult	• Capital costs significantly higher than surface barrier • Similar long term monitoring and maintenance costs	No - Minor degree of additional protectiveness does not offset concerns associated with implementability, short term worker exposure and higher costs
In Situ Grouting	• Prevents direct exposure • Reduces contaminant mobility through treatment • Long term stability of grouted matrix • VOCs in high organic waste streams destroyed with ISTD	• Researched for INEEL specific application • Long implementation period • Requires extensive intrusive work • Requires the implementation of ISTD technology to pretreat high organics areas	• Capital costs higher than Surface Barrier • Long term monitoring and maintenance costs	Yes - Alternative meets RAOs and provides for a further reduction in containment mobility
In Situ Vitrification	• Prevents direct exposure • Reduces contaminant toxicity, mobility, and volume through treatment • Provides a more stable long term matrix • Activation/fission products in SVRs and trenches stabilized with ISG	• Specialized equipment required • Long implementation period • Concerns associated with potential worker exposure and contaminant release during implementation • Requires implementation of ISTD technology to pretreat wastes • Site-specific technology applications must be proven	• Capital costs higher than ISG • Long term monitoring and maintenance costs could be reduced	Yes - Alternative meets RAOs and provides for improved stability of waste form
Retrieval/ Treatment/ Disposal	• Prevents long term direct exposure • Highest potential short term exposures • Reduces contaminant toxicity, mobility, and volume through treatment • Removes all TRU wastes from source areas • Activation/fission products in SVRs and trenches stabilized with ISG	• Very long implementation period • Requires specialized contamination control/retrieval equipment • Regulatory concerns associated with off-site disposal of TRU wastes • Site-specific technology applications must be proven	• Highest capital costs associated with contamination control/retrieval equipment, characterization, and treatment • Long term monitoring and maintenance costs can be minimized	Yes - Alternative meets RAOs by removing buried TRU waste

E6. DETAILED ANALYSIS OF ALTERNATIVES

Each of the alternatives retained after the initial screening are feasible for WAG 7. In Section 4, the retained alternatives are subjected to a detailed analysis, which assesses the degree to which an alternative satisfies the CERCLA evaluation criteria. Design elements and strategies are evaluated to determine the projected performance of each alternative against the threshold and balancing criteria shown in Table E-3. The modifying criteria will be applied to each alternative during the proposed plan and record of decision phases of the CERCLA process.

Table E-3. Comprehensive Environmental Response, Compensation and Liability Act evaluation criteria.

Category	Criteria
Evaluated during preliminary evaluation of remedial alternatives	
Threshold	Overall protection of human health and the environment
	Compliance with applicable or relevant and appropriate requirements
Balancing	Long-term effectiveness and permanence
	Reduction of toxicity, mobility, or volume through treatment
	Short-term effectiveness
	Implementability
	Cost
Evaluated during proposed plan and the record of decision	
Modifying	State acceptance
	Community acceptance

Evaluation of each alternative is supported by the tabulated summary presented in Appendix C. A brief synopsis of each alternative is presented below.

E6.1 No Action Alternative

E6.1.1 Alternative Description

A no action alternative is evaluated in accordance with requirements of the National Contingency Plan regulations (40 CFR 300.430[e][6]) and by EPA guidance for conducting feasibility studies under CERCLA (EPA 1988). The alternative serves as the baseline for comparing remedial action alternatives. For WAG 7, this alternative would include only long-term monitoring of groundwater, vadose zone moisture, soil, surface water, and air, with no direct action to treat, stabilize, or remove contaminants.

> **No Action Alternative Remediation Strategy**
>
> Existing site conditions will remain unchanged. No action will be taken to reduce contaminant mobility, toxicity, or volume.
>
> **Key Element:**
> Long-term monitoring.

E6.1.2 Evaluation of Comprehensive Environmental Response, Compensation and Liability Act Criteria

This comparatively inexpensive alternative would be easily implemented, incurring only the costs associated with long-term monitoring. However, the alternative offers no reduction in the mobility, toxicity, or volume of contaminants within the SDA. Therefore, the No Action alternative does not meet RAOs.

E6.2 Surface Barrier Alternative

E6.2.1 Alternative Description

The Surface Barrier alternative consists of institutional controls, physical barriers, and long-term operation and maintenance. The physical barrier is achieved by placing a multilayer, low-permeability cover system over the site. An INEEL-specific design was identified as the representative technology, which consists of interlayered sequences of soil and rock having a minimum overall thickness of approximately 18 ft. Cover layers are designed to prevent human and ecological receptors from direct contact with the buried waste. The cover would stabilize contaminants in place and minimize migration through leaching, volatilization, or biotic uptake. The surface barrier system has a 1,000-year design life.

The Surface Barrier alternative includes ISG on selected waste-disposal areas within the SDA, including locations where elevated levels of C-14 and other COCs are present. Other locations would be subject to foundation grouting as necessary to ensure a stable foundation for a protective cap that would cover the entire SDA. Pad A waste would be retrieved and placed in a more stable configuration within the central portion of the SDA to minimize future subsidence-related damage to the surface barrier. High organic areas would be pretreated with ISTD to minimize future operational requirements for the OCVZ system.

Surface Barrier Alternative Remediation Strategy

The isolation of the buried waste and the reduction of contaminant migration through the placement of a long-term, low-permeability cover system.

Key Elements:

(1) In situ grouting at selected disposal sites
(2) In situ thermal treatment in areas with high volatile organic contaminant
(3) Pad A retrieval and reconfiguration
(4) Foundation stabilization
(5) Long-term multilayer cover
(6) Physical and administrative land-use restrictions
(7) Long-term monitoring and maintenance.

E6.2.2 Evaluation of Comprehensive Environmental Response, Compensation and Liability Act Criteria

The Surface Barrier alternative provides overall protection of human health and the environment, complies with ARARs, offers long-term effectiveness and permanence, and poses few implementation challenges. While it will reduce mobility of contaminants, it will not reduce toxicity or volume. The alternative poses low risk to the community during remediation, and risks to remediation workers can be mitigated with appropriate equipment and training. Though the Surface Barrier alternative meets the RAO limiting incremental excess cancer risk to less than or equal to 1E-04, fate and transport modeling predicts long-term reduction of carcinogenic risk is expected to be less than that for the ISG, ISV, and RTD alternatives. Estimated cost of the Surface Barrier alternative is the lowest of the action remedial alternatives.

E6.3 In Situ Grouting Alternative

E6.3.1 Alternative Description

The ISG alternative would encapsulate buried waste in a stable grout monolith designed and implemented to reduce contaminant migration from the site. Scope of the technology application would encompasses burial sites containing the RFP TRU waste and additional areas containing activation and fission product COCs. Specific areas would require pretreatment before grouting to reduce the mass of organics within the waste. Pad A waste would be retrieved and subjected to ex situ treatment to ensure compliance with RAOs. A low-permeability surface cap would be constructed to isolate the in situ-treated waste from future human and ecological receptors.

In Situ Grouting Alternative Remediation Strategy

Stabilizing buried waste through ISG. Future exposure to the stabilized waste would be prevented through implementing administrative and physical land-use restrictions, including placement of a low-permeability, biotic barrier cover system.

Key Elements:
(1) In situ grouting of buried waste
(2) Retrieval and ex situ stabilization of Pad A waste
(3) Pretreatment of high organic areas using in situ thermal desorption
(4) Placement of low-permeability cover system
(5) Physical and administrative land-use restrictions
(6) Long-term monitoring and maintenance.

E6.3.2 Evaluation of Comprehensive Environmental Response, Compensation and Liability Act Criteria

The ISG alternative provides overall protection of human health and the environment, complies with ARARs, and offers long-term effectiveness and permanence. Specialized equipment would be required for implementation, but such equipment has been researched for use at the INEEL. The alternative would substantially reduce contaminant mobility, but would not reduce toxicity or volume. Uncertainties associated with treatment processes required for Pad A waste to comply with ARARs or achieve risk-based levels have not been resolved. Risks to remediation workers include physical hazards involving equipment operation. Exposed waste poses a low-potential risk of direct radiation or inhalation. These risks would be mitigated with appropriate training, engineering and administrative controls, and personal protective equipment. Estimated cost of the ISG alternative is the second highest of the remedial action alternatives.

E6.4 In Situ Vitrification Alternative

E6.4.1 Alternative Description

The ISV alternative entails in situ treatment of buried waste within the SDA with applications of ISV. The ISV technology would remove and destroy organic constituents waste and encapsulate most inorganic constituents within a durable, glass-like monolith. This stable waste form would reduce the potential of hazardous constituents migrating to adjacent media.

The alternative also includes applying ISG to locations where activation and fission COCs are located. Placement of a low-permeability surface cap over the SDA would further isolate in situ-treated waste from human and ecological receptors. Foundation grouting would be applied as necessary to ensure a stable foundation for the cap.

In Situ Vitrification Alternative Remediation Strategy

Stabilizing and treating buried waste with in situ vitrification and selective in situ grouting. Contaminants would either be destroyed or immobilized in glass-like monoliths (and grout monoliths) reducing migration to adjacent media to acceptable levels. Future exposure to the stabilized waste would be prevented through implementing administrative and physical land-use restrictions and would include placement of a low-permeability and biotic barrier cover system.

Key Elements:

(1) In situ vitrification with in situ thermal desorption pretreatment
(2) Reconfiguration of the Pad A waste for in situ vitrification treatment
(3) Selective in situ grouting of buried waste
(4) Foundation grouting
(5) Placement of low-permeability cover system
(6) Physical and administrative land-use restrictions
(7) Long-term monitoring and maintenance.

E6.4.2 Evaluation of Comprehensive Environmental Response, Compensation and Liability Act Criteria

The ISV alternative provides overall protection of human health and the environment, though uncertainties exist about protecting remediation workers and preventing potential release of contaminants during remediation. It complies with ARARs and offers long-term effectiveness and permanence. The alternative would substantially reduce mobility of contaminants and destroy organics within targeted waste. Toxicity and volume of other contaminants will not be reduced.

Effectiveness and implementability of this technology on variable waste conditions present at the SDA need further verification. Risks to workers include physical hazards involving equipment operation, exposure to fugitive dust during construction, and potential melt expulsion events (contaminated material returning to the surface during the subsurface vitrification process). Risks associated with physical hazards and fugitive dust would be mitigated with appropriate training, engineering and administrative controls, and personal protective equipment. Mitigating melt expulsion events would require pretreating waste (using ISTD) and placing a protective 10-ft soil layer over the melt area. Further research would be needed to establish implementation requirements necessary to apply this technology to the SDA. Estimated cost of the ISV alternative is third highest of the four remedial action alternatives.

E6.5 Retrieval, Treatment, and Disposal Alternative

E6.5.1 Alternative Description

The RTD alternative involves the retrieval, ex situ treatment, and disposal of the RFP TRU waste. The alternative includes applying ISG to the soil vault rows and trench areas containing activation and fission product COCs. In addition, ISTD would be implemented in the high organic waste areas to minimize material handling requirements during retrieval actions.

The basic strategy of this alternative is that TRU waste and soil would be retrieved from the SDA, characterized, treated as required to meet waste acceptance criteria, packaged, and then transported to the deep geologic repository at the Waste Isolation Pilot Plant (WIPP) in New Mexico. All other retrieved material, including low-level waste (LLW) and mixed low-level waste (MLLW), would be treated and disposed of onsite in an engineered disposal facility. Excavated areas sites would be backfilled, and a multilayer low-permeability cap would be constructed over the entire SDA.

Retrieve, Treat, and Disposal Alternative Remediation Strategy

The retrieval and ex situ treatment of buried waste material. Retrieved TRU waste would be transported off-Site to the Waste Isolation Pilot Plant (WIPP) for disposal. All other retrieved waste would be treated and disposed of onsite in an engineered long-term facility.

Key Elements:
(1) Waste retrieval
(2) Ex situ treatment
(3) Transuranic waste disposal at WIPP
(4) Low-level waste and mixed low-level waste disposal at an onsite landfill
(5) Selective in situ grouting at designated waste sites
(6) In situ thermal desorption in areas with high volatile organic contaminants
(7) Installation of cap
(8) Institutional controls
(9) Long-term monitoring and maintenance.

E6.5.2 Evaluation of Comprehensive Environmental Response, Compensation and Liability Act Criteria

The RTD alternative complies with ARARs, offers long-term effectiveness and permanence, and provides protection of human health and the environment. While this alternative involves a highly complex remediation strategy, it would reduce mobility, toxicity, and volume of contaminants through removal, treatment, and disposal of TRU waste. The alternative's ability to retrieve and treat waste to meet regulatory requirements or waste acceptance criteria requires verification. Off-Site disposal of TRU waste poses implementation uncertainties related to available WIPP capacity and required traffic control measures that would be necessary to protect communities through which waste is transported. The alternative includes substantial earthwork and waste excavation operations, which pose short-term risks to the community and remediation workers that are higher than those associated with other alternatives. Risks to workers include physical hazards involving equipment operation and direct radiation and inhalation hazards from the exposed buried waste. Remote-operated and other specialized equipment would be required to reduce risk to workers during retrieval and construction activities. Additional research would be needed to develop appropriate engineering controls to address possible contaminant release events during retrieval and treatment.

The RTD alternative also involves issues of technical and administrative feasibility that include obtaining, designing, and building specialized equipment capable of handling variable waste streams and materials. A high potential exists for schedule delays that may be caused by the numerous systems required and the need for first-of-their kind retrieval and treatment facilities. Administratively, transportation, air emissions, and disposal issues would require negotiation and coordination with multiple agencies across multiple states. Estimated cost of the RTD alternative is the highest of the five remedial action alternatives.

E7. COMPARATIVE ANALYSIS OF ALTERNATIVES

Directly following the detailed analysis, Section 5 provides the comparative analysis of alternatives, which identifies differences between the alternatives that might make one slightly more effective or implementable. However, because of the complexity and inherent uncertainty of comparative evaluations, precise rankings of each alternative based on dissimilar advantages and disadvantages cannot developed. However, the qualitative comparison based on the CERCLA criteria can be used to support remedial decision making for WAG 7. The cost information for each alternative is summarized from the detailed estimates that appear in Appendix D. Table E-4 summarizes results of the comparative analysis process.

Notably, the PERA neither prioritizes the alternatives nor promotes any single one as the preferred remedy. Instead, the PERA provides extensive information for a range of alternatives that decision makers and stakeholders can use to develop informed opinions about advantages and disadvantages of any alternative being considered for WAG 7. Ultimately, the DOE, EPA, and State of Idaho will determine which of the feasible alternatives will be proposed as the preferred alternative for WAG 7 after addressing the modifying CERCLA criteria of state and community acceptance.

Table E-4. Comparative analysis of alternatives.

Criteria	Alternatives: No Action	Surface Barrier	In Situ Grouting	In Situ Vitrification	Retrieval/ Treatment/ Disposal
Overall protection of human health and the environment	• Does not address RAOs • Does not provide for the overall protection of human health and the environment	• Addresses RAOs • Immobilizes and isolates COC bearing wastes through capping • Destroys organic COCs in high concentration waste streams using ISTD • Immobilizes activation/fission product COCs using ISG	• Addresses RAOs • Immobilizes COC bearing wastes using ISG • Destroys organic COCs in high concentration waste streams using ISTD	• Addresses RAOs • Immobilizes and destroys wastes using ISTD/ISV • Immobilizes activation/fission product COCs using ISG	• Addresses RAOs • Removes TRU wastes from site • Non TRU COC bearing waste streams will be retrieved, treated and placed in on-site engineered landfill • Immobilizes remaining COC wastes using ISG
Compliance with ARARs	• Not compliant	• Potentially compliant	• Potentially compliant	• Potentially compliant	• Potentially compliant
Long term protectiveness and permanence	• Does not provide for long term protectiveness	• Provides long term protectiveness • Long term maintenance required to insure protectiveness	• Provides long term protectiveness • Potentially permanent solution • Long term maintenance required to insure protectiveness	• Provides long term protectiveness • Potentially permanent solution • Long term maintenance required to insure protectiveness	• Provides long term protectiveness • Permanently removes risks associated with TRU wastes • Long term maintenance required to insure protectiveness
Reduction of toxicity mobility and volume through treatment	• Does not reduce source toxicity, mobility, or volume	• ISG treatment reduces contaminant mobility in SVRs and trenches. • ISTD treatment reduces organic COC volumes in high concentration waste streams.	• Reduces contaminant mobility in all COC bearing wastes	• Reduces contaminant mobility, toxicity and volume in all COC bearing wastes	• Removes TRU wastes • Ex situ treatment will reduce toxicity, mobility, and volume of retrieved non-TRU wastes from pits, trenches, and Pad A. • ISG treatment reduces contaminant mobility in SVRs and trenches.
Short term effectiveness	• Lowest worker risk	• Minimal intrusive work requirements	• Contamination control for ISG researched for INEEL specific application	• Contamination control for ISV has not been proven. • Higher potential worker risk	• Extensive intrusive work requirements • Highest risks to workers and off-site communities
Implement-ability	• Easily implemented	• Primary technology (surface barrier) consists of standard earthwork operation.	• Primary technology (ISG) has been researched for SDA specific application.	• Primary technology (ISV) requires specialized equipment.	• Requires complex interaction of remedial activities and technologies with site-specific designs
Costs	Total Cost **$ 38.5M** Net Present Value **$ 9.6M**	Total Cost **$841.6M** Net Present Value **$616.1M**	Total Cost **$1,118M** Net Present Value **$ 822.6M**	Total Cost **$1,815.3M** Net Present Value **$1,197.3M**	Total Cost **$6,889.1M** Net Present Value **$3,779.7M**

Initial development of the WAG 7 feasibility study has been completed in the PERA, which provides the basis for developing RAOs, GRAs, technology and process option screening, and assembly of alternatives. The focus of subsequent feasibility study efforts will be to refine and update the detailed analysis of alternatives presented in Section 4 and revise the comparative analysis to present an objective evaluation of benefits, deficiencies, and cost comparison of the respective remedial alternatives. Recommended areas of refinement include:

- Define with more precision waste areas or volumes that require remediation using data from probing and probehole monitoring, waste inventory updates, and updates to WasteOScope (INEEL 2001)
- Identify and quantify waste streams that could impede remediation and identify their locations
- Refine the evaluation of long-term effectiveness and permanence and reduction of mobility, toxicity and volume through treatment using results from the bench-scale tests; in particular enhance the ISTD effectiveness evaluation
- Refine waste form parameters for the feasibility study risk assessment modeling using results from the bench-scale tests and updated information from scientific literature
- Examine in-depth technical and administrative issues associated with implementing the alternatives using results of safety and hazard assessments and revise the short-term effectiveness and implementability evaluations for the alternatives
- Define further the WIPP waste acceptance criteria and process as it would apply to the RTD alternative and define procedures for characterizing and packaging waste
- Review assumptions to cost estimates and revise as required.

E8. REFERENCES

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FIGURES

TABLES

ACRONYMS

ABRA	Ancillary Basis for Risk Analysis of the Subsurface Disposal Area
ALARA	as low as reasonably achievable
AMWTP	Advanced Mixed Waste Treatment Project
AOC	area of contamination
ARAR	applicable or relevant and appropriate requirement
BMP	best management practices
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	contaminant of concern
CSE	criticality safety evaluation
D&D&D	deactivation, decontamination, and decommissioning
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
EPA	U.S. Environmental Protection Agency
ESRP	Eastern Snake River Plain
FFA/CO	Federal Facility Agreement and Consent Order
GRA	general response action
HEPA	high-efficiency particulate air (filter)
ICDF	INEEL CERCLA Disposal Facility
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Environmental Quality
INEEL	Idaho National Engineering and Environmental Laboratory
IRA	Interim Risk Assessment
ISG	in situ grouting
ISTD	in situ thermal desorption

ISV	in situ vitrification
LDR	land disposal restrictions
LLW	low-level waste
MACT	maximum achievable control technology
MCL	maximum contaminant level
MLLW	mixed low-level waste
NAAQS	National Ambient Air Quality Standards
NCP	National Contingency Plan
NDA	nondestructive assay
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
OCVZ	organic contamination in the vadose zone
OU	operable unit
PCE	tetrachloroethylene (synonyms: perchloroethylene and tetrachloroethene)
PERA	Preliminary Evaluation of Remedial Alternatives
PPE	personal protective equipment
PRG	preliminary remediation goal
QA	quality assurance
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RFP	Rocky Flats Plant
ROD	record of decision
RI/FS	remedial investigation/feasibility study
RWMC	Radioactive Waste Management Complex
RTD	retrieval, treatment, and disposal
SDA	Subsurface Disposal Area

SOW	scope of work
SVR	soil vault row
SVOC	semivolatile organic compounds
SRPA	Snake River Plain Aquifer
TBC	to be considered
TRAMPAC	TRUPACT-II Authorized Methods for Payload Control
TRUPACT-II	Transuranic Package Transporter Model 2
TSA	Transuranic Storage Area
TSD	treatment, storage, and disposal
TRU	transuranic
VOC	volatile organic compound
WAC	waste acceptance criteria
WAG	waste area group
WIPP	Waste Isolation Pilot Plant